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THE PRODUCTION OF SWEET-ORANGE OIL AND A NEW MACHINE FOR PEELING CITRUS FRUITS.

POSSIBILITY OF THE COMMERCIAL PRODUCTION OF SWEET-ORANGE OIL FROM WASTE ORANGES.

By S. C. Hood, *Scientific Assistant*, and G. A. Russell, *Expert, of Office Drug-Plant and Poisonous-Plant Investigations.*

CONTENTS.

	Page.
Introduction	1
Importance of the industry	2
Material available for the production of orange oil	4
Methods of extraction	5
Pressed oil	6
Comparison of the various oils	9
Commercial possibilities	10
Cost of production	11
Yield of oil	11
Summary	12

INTRODUCTION.

The oil extracted from the fresh peel of the sweet orange has long been an important article of commerce in the United States and Europe. It is extensively used in the manufacture of flavoring extracts, perfumes, and soaps, and to a small extent in the drug trade, the oil being official in the ninth decennial revision of the United States Pharmacopœia. Until recently, this product was secured wholly from Italy, Sicily, and other parts of southern Europe. Since the year 1911, however, a considerable industry has grown up in the West Indies, and a portion of the annual requirement in the United States is now supplied from that region.

The methods of extracting sweet-orange oil are similar in all countries wherever practiced. The fruit is peeled by hand, either by cutting it in half crosswise and scooping out the pulp or by stripping off the peel in three longitudinal pieces. The peel thus secured is inverted and pressed over a small sponge. By this means the oil

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Note.—This bulletin is of interest to growers of oranges generally.

cells of the outer part of the peel are ruptured and the mixture of oil and other liquids is forced out in a fine spray. After the sponge has become saturated, the contents are squeezed into a bowl, and the oil is eventually drained off the accumulated liquid. From time to time various machine methods have been tried, but apparently none of them has proved satisfactory. Furthermore, when the peel is pressed in quantity by machinery an emulsion is formed from which it is very difficult to separate the oil. Accordingly, almost the entire output of sweet-orange oil is extracted by the hand-pressing method.

IMPORTANCE OF THE INDUSTRY.

Complete figures on the total world production of sweet-orange oil are not available, but the annual exports from Italy and Sicily, which represent a large portion of the world's production, have been compiled from various sources and are given in Table I.

TABLE I.—*Export of sweet-orange oil from Italy and Sicily for the years 1906 to 1913, inclusive.*

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Pounds.			*Pounds.*	
1906	301,455	$666,984	1910	285,357	$415,065
1907	357,749	782,972	1911	90,078	131,021
1908	381,980	735,683	1912	118,366	193,691
1909	498,705	770,725	1913	105,826	202,033

It will be seen from Table I that in 1911 there was a marked decrease in the exports and that in the two following years the quantity exported was much lower than in the six preceding years. This decline is due in part to a small crop of oranges in Italy in 1911, in part to a heavy import tax levied in this country, and in part to the activity of producers in the West Indies, which region is now producing a quantity nearly sufficient to meet the American as well as the British demand.

The imports of sweet-orange oil entered for consumption in the United States are shown in Table II.

TABLE II.—*Imports of sweet-orange oil into the United States from all sources for the years 1900 to 1914, inclusive.*

[Compiled from Commerce and Navigation of the United States.]

Year.	Quantity.	Value.	Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Pounds.			*Pounds.*			*Pounds.*	
1900	57,069	$95,405	1905	92,077	$143,555	1910	46,814	$65,488
1901	72,218	109,832	1906	74,535	122,634	1911	73,786	100,115
1902	79,160	104,159	1907	112,834	199,027	1912	97,065	168,831
1903	77,138	107,808	1908	71,224	165,982	1913	77,797	155,299
1904	74,816	109,478	1909	87,591	151,861	1914	104,597	222,118

The price of sweet-orange oil is subject to considerable variation, the extent of which is influenced both by the relative abundance of the orange crop in the regions where this oil is produced and also by market speculation. Table III gives the prices paid by jobbers, in January, June, and December, for a period of 10 years for Italian hand-pressed oil from Messina, Italy, delivered in New York City.[1]

TABLE III.—*Prices of Italian hand-pressed sweet-orange oil, f. o. b. New York, for the years 1905 to 1914, inclusive.*

Year.	Price per pound.			Year.	Price per pound.		
	January.	June.	December.		January.	June.	December.
1905	$1.521	$1.744	$1.764	1910	$1.338	$1.379	$1.379
1906	1.974	1.947	1.947	1911	1.541	1.541	1.906
1907	1.987	2.068	2.109	1912	1.886	1.926	2.271
1908	2.149	1.501	1.399	1913	2.616	3.569	3.042
1909	1.886	1.399	1.379	1914	2.636	1.947	1.318

Table IV gives the wholesale market prices for the Italian hand-pressed oil for a period of 10 years, as quoted in the Oil, Paint, and Drug Reporter. These figures represent the high and low prices quoted at the middle of each month. From Tables III and IV, therefore, can be noted the difference between the prices paid the producer by the jobber and the prices asked for the oil in the wholesale market.

TABLE IV.—*Monthly market quotations for Italian hand-pressed sweet-orange oil for the years 1906 to 1915, inclusive.*

Month and price.	Year.									
	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915
January:										
Low	$2.00	$2.10	$2.45	$2.50	$2.20	$2.25	$2.40	$2.70	$3.00	$1.60
High	2.25	2.30	2.60	3.00	2.25	2.30	2.50	3.00	3.25	1.75
February:										
Low	2.10	2.10	2.40	2.10	2.20	2.25	2.45	2.90	2.75	1.55
High	2.25	2.30	2.60	2.25	2.40	2.30	2.60	3.25	3.00	1.75
March:										
Low	2.20	2.15	2.25	2.00	2.25	2.25	2.55	3.00	2.65	1.50
High	2.35	2.25	2.50	2.25	2.50	2.30	2.65	3.25	2.80	1.60
April:										
Low	2.10	2.20	2.20	1.90	2.25	2.20	2.45	2.90	2.60	1.55
High	2.25	2.25	2.40	2.10	2.50	2.25	2.60	3.10	2.80	1.60
May:										
Low	2.10	2.10	2.10	1.80	2.25	2.20	2.45	3.00	2.30	1.65
High	2.25	2.25	2.25	2.00	2.50	2.30	2.60	3.15	2.35	1.85
June:										
Low	2.10	2.10	1.80	1.75	2.20	2.25	2.45	3.25	2.20	1.75
High	2.25	2.25	2.00	1.90	2.50	2.35	2.50	3.50	2.40	2.00
July:										
Low	2.10	2.40	1.70	1.80	2.20	2.35	2.45	3.50	2.15	2.00
High	2.25	2.50	1.90	2.00	2.50	2.40	2.60	3.75	2.30	2.25
August:										
Low	2.20	2.25	1.65	2.00	2.20	2.45	2.45	3.75	4.00	1.85
High	2.35	2.35	1.90	2.25	2.50	2.60	2.60	4.00	4.25	2.00
September:										
Low	2.20	2.25	1.70	1.90	2.15	2.55	2.60	3.90	3.25	1.80
High	2.35	2.35	1.90	2.10	2.25	2.70	2.70	4.25	3.75	2.15
October:										
Low	2.20	2.30	1.60	1.90	2.15	2.50	2.60	4.00	1.80	1.75
High	2.35	2.50	1.90	2.10	2.25	2.60	2.75	4.25	2.00	2.00
November:										
Low	2.20	2.45	1.65	2.00	2.15	2.40	2.60	3.40	1.60	1.65
High	2.35	2.60	1.90	2.10	2.25	2.60	2.70	3.50	1.75	1.75
December:										
Low	2.15	2.40	1.65	2.05	2.20	2.40	2.65	3.20	1.50	1.85
High	2.20	2.60	1.90	2.20	2.25	2.50	2.75	3.40	1.75	1.90

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[1] Haven, J. F. Essential oils in Italy. *In* Amer. Perfumer, v. 10, no. 7, p. 175. 1915.

MATERIAL AVAILABLE FOR THE PRODUCTION OF ORANGE OIL.

In the commercial production of oranges there is always a greater or less quantity of waste fruit. Oranges which are defective in shape or which show even slight blemishes on the skin are rejected and thrown out on the cull heap (fig. 1). The quantity thus rejected varies according to the season, to the variety of fruit, and to the care which is given to the production of the crop, but even under the most favorable conditions it is considerable. With the increasing tendency to grade the fruit more closely and to better the market conditions, the proportion of culls will doubtless increase rather than decrease.

A considerable loss results also from the dropping of the fruit in the groves throughout the winter months. Certain varieties show this tendency regularly, although all varieties have a tendency to drop the fruit when held for market advances under unfavorable climatic conditions.

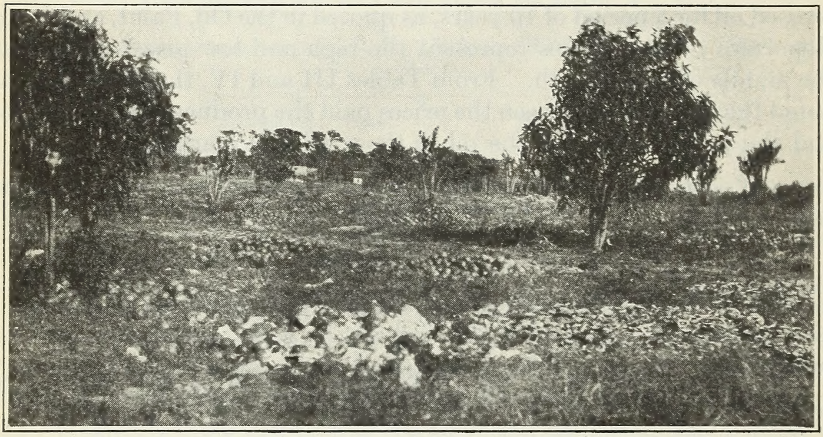

FIG. 1.—Piles of cull oranges in a grove.

In addition to these sources of available material it is possible to obtain a quantity of low-grade fruit. At present this low-grade fruit, packed in so-called "plain wraps," is sometimes shipped to near-by markets for immediate consumption. The returns are exceedingly small, especially in years when the crop is abundant. It is believed, however, that with greater attention to marketing conditions this inferior fruit can be more profitably utilized in the manufacture of by-products and thus open a wider field for the better grades. At the present time there is without doubt enough low-grade fruit available to make possible the extraction of a quantity of orange oil sufficient to supply a considerable portion of the domestic demand.

METHODS OF EXTRACTION.

For use in these experiments a new type of peeling machine[1] was devised which removes the peel and at the same time ruptures the oil cells. As the peel comes from the machine it is in a finely divided condition (fig. 2) and the oil cells are practically all opened. The oil being thus released from the cells is more or less absorbed by the spongy remainder of the peel. The outer portion of the peel, in which the oil cells are contained, is of course the first to be removed by the machine, and experiments have shown that the peel removed by the first third of the length of the grating drum contains approximately 76 per cent of the oil; that removed by the second third contains about 23 per cent, while that from the last third has less than 1 per cent of oil. For this reason it was found economical to discard the peel removed by the last third of the grating drum and to employ only that removed by the first two thirds.

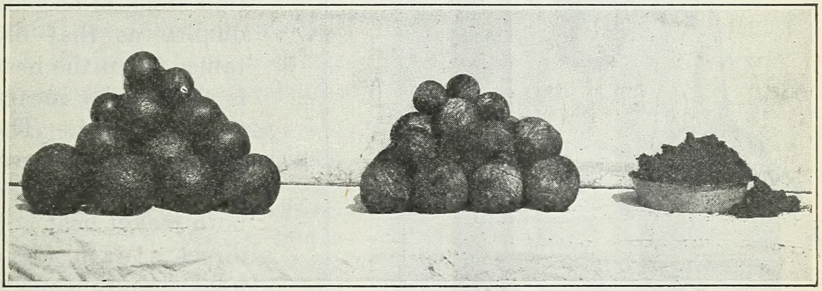

FIG. 2.—Oranges before and after peeling and the finely divided peel.

In order to recover the oil, distillation by both steam and vacuum was employed. It was found, however, that the oil obtained by means of steam distillation was not of good quality. It was either water white or pale yellow in color and possessed to only a very slight degree the valuable odor-bearing and flavoring constituents desirable in orange oil.

For distilling under vacuum a special type of apparatus is necessary (fig. 3). This apparatus consists of a copper retort connected with a condenser and so arranged that nearly all the air within the apparatus can be removed by means of a vacuum pump. Distillation is then accomplished either by means of heat from the steam jacket or by direct admission of steam into the retort.

The peel is first mixed with water to form a fairly thin paste. This mixture is then placed in the retort, the cover clamped down, and all connections made air-tight. The vacuum pump is next started and the air exhausted from the apparatus. As the air pressure becomes less the pressure can be read by means of a gauge attached to the distilling apparatus. When the gauge indicates sufficient diminution in the pressure, steam is admitted into the jacket of the retort. The thin mixture of water and peel begins to boil almost immediately, and the water vapors passing into the condenser carry the oil with them. Here the vapors are condensed and the distillate is collected in the receiver. The oil being lighter than water floats on the surface and can easily be separated. The peel is exhausted in about 30 minutes. Steam can also be admitted directly into the retort and the oil extracted under diminished pressure by direct steam. The oil obtained by vacuum distillation was light lemon yellow in color and possessed a pleasing orange odor and the characteristic aromatic orange taste.

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[1] A detailed description of this machine, covered by United States Letters Patent No. 1186317, dedicated to the public, is given in the second part of this bulletin, pages 13 to 19.

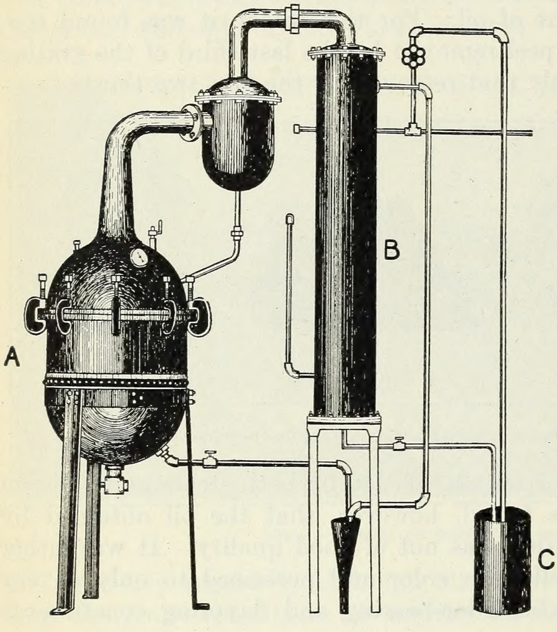

FIG. 3.—Experimental vacuum still used in extracting orange oil: *A*, Still; *B*, condenser; *C*, receiver.

The oil obtained by direct steam distillation is not of as good quality as that obtained when the heat is applied by means of the jacket. The best results, however, were obtained when both jacket heat and direct steam were used simultaneously. The oil obtained was macerated with 20 per cent of its weight of fresh unextracted peel and then filtered. Thus treated, the oil had a lemon-yellow color with a slight tinge of brown. It had an excellent orange odor and the characteristic aromatic orange taste. Apparently the odor-bearing and flavoring constituents are all present and by the method described a fair grade of orange oil can be prepared.

PRESSED OIL.

Pressed orange oil is generally understood to mean the oil which is pressed from the peel by hand. Where labor is cheap such a method of extraction is economically possible, but where labor is relatively costly this method can not be used. Accordingly, methods were worked out for applying heavy pressure without any great outlay of money for hydraulic presses.

In some preliminary experiments it was noted that when a portion of the vacuum-distilled oil was macerated with unpressed peel for several hours the loss in the volume of the oil recovered was in some instances as high as 10 per cent. Some oil had been absorbed by the peel, although the peel employed contained all its original content of oil. When pressure was applied to this macerated peel all the original oil could be pressed out. A portion of the peel pressed before maceration yielded about 95 per cent of its original oil content. When, however, the press cake was distilled with water and the oil thus produced used to macerate the next lot of peel to be pressed, the yield of oil obtained was approximately the original content of the peel. With these facts in mind, the following method was devised for extracting sweet-orange oil by pressure:

An inexpensive press (fig. 4) was employed in the experimental work. This press consists of a heavy wooden frame, a wooden drum fitted with a perforated brass cylinder, and a heavy screw for applying pressure. About 20 pounds of the finely ground peel from the first two-thirds of the grating drum was placed in a canvas sack made of 10-ounce duck and the sack placed in the wooden drum. Pressure was then applied by means of the heavy screw. Before pressing, the peel was thoroughly mixed with approximately one-half its weight of water and the whole heated to not over 90° C. The oil and water pressed out were collected in a large container, where the oil came to the top and the water was easily removed.

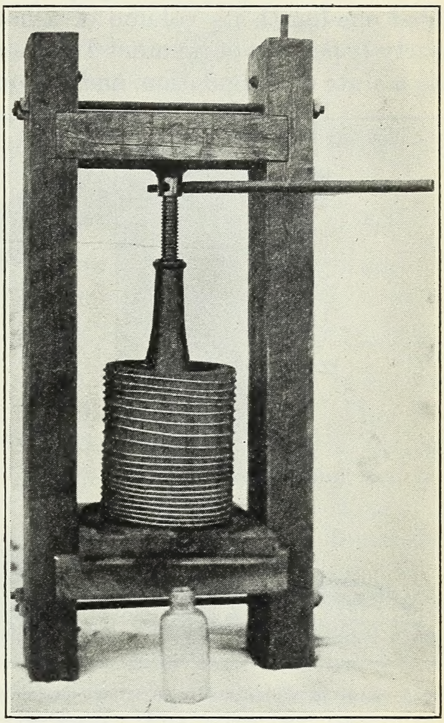

FIG. 4.—Experimental press used in extracting orange oil.

The press cake was then thrown into a still (fig. 5, *a*) and distilled with water. A small quantity of oil was thus secured which was added to the next lot of peel and the mixture allowed to macerate for a short time. After pressing several lots the mixture of oil and water was placed in a separatory funnel (fig. 5, *d*) and all the water possible was removed.

The oil thus obtained formed a thick emulsion with a portion of the water. This emulsification was brought about by means of a gumlike substance which was pressed from the ground peel. The mixture thus formed was found to resist all the regular methods for breaking emulsions. Centrifuging did not throw out the oil, but, on the contrary, more completely emulsified it. Treatment with kieselguhr (infusorial earth) and subsequent filtering under difference in pressure yielded a clear oil, but the process was entirely too slow in operation. After several experiments the following method was found to work very satisfactorily.

All the water possible was removed with a separatory funnel, and the emulsion warmed on a water bath to not over 90° C. To this was added one-tenth its volume of a hot solution containing 2 per cent of gelatin and the whole thoroughly mixed. To the warm mixture was added one-fourth its volume of a hot solution containing approximately 10 per cent of tannin. The emulsifying agent was thus brought into a state of coagulation, and the oil was released. The mass was now thrown into a sack made of heavy Canton flannel and again pressed. The oil and water thus pressed out were separated by means of the separatory funnel, and the oil dried with quicklime and filtered. The filtered oil constitutes the marketable product.

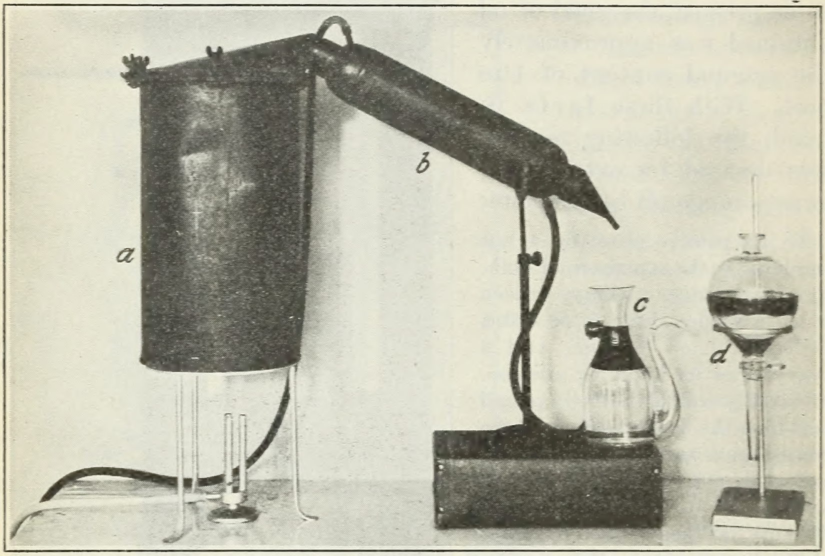

FIG. 5.—Experimental still used in extracting orange oil: *a*, Still; *b*, condenser; *c*, receiver; *d*, separatory funnel.

When the method was thus proved to be practicable, a cheap and abundant supply of tannin was sought. This was found in the rhizome of the common saw palmetto, which contains approximately 7.58 per cent of tannin.[1] A portion of this rhizome was boiled with water in a copper vessel for several hours and the liquor then strained off. Ten pounds of the fresh rhizome was found to yield a supply of tannin solution sufficient to treat the emulsion from at least a ton of oranges.

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[1] Trimble, H. The tannins of the palmettos. *In* Gard. and Forest, v. 9, no. 428, p. 182-183. 1896.

COMPARISON OF THE VARIOUS OILS.

In order that the oils obtained by the processes outlined might be compared with commercial imported Italian hand-pressed oil, a sample of the latter was purchased in the open market, and the results of the comparison are shown in Table V.

TABLE V.—*Comparison of the oils obtained by vacuum distillation and by pressing with a commercial sample of hand-pressed imported oil.*

Description of oil.	Color.	Odor.	Taste.	Specific gravity, at 25° C.	Specific rotation ($[\alpha]_d$), at 25° C.	Evaporation residue.	Total absorption by sodium bisulphite.
						Per cent.	*Per cent.*
Italian hand pressed.	Lemon yellow.	Characteristic orange.	Characteristic, aromatic; no bitterness.	0.8415	115° 6′	1.73	2.92
Florida:							
Vacuum distilled.	Lemon yellow, with slight brown tinge.	.....do.........	.....do.........	.8423	115° 18′	2.10	2.66
Machine pressed.	Reddish yellow.	Characteristic orange; excellent fruity aroma.	.....do.........	.8445	109° 36′	2.90	4.00

Sweet-orange oil is graded on the market according to its color, odor, taste, specific gravity, and angle of rotation. The ninth decennial revision of the United States Pharmacopœia describes orange oil as a yellow liquid, having the characteristic odor and taste of orange peel. The specific gravity, at 25° C., lies between 0.842 and 0.846; the optical rotation is not less than +94° in a 100-mm. tube at 25° C.

Table V reveals some interesting comparisons. The color of the pressed oil as given is reddish yellow, due entirely to coloring matter which was forced out by the heavy pressure used in extracting the oil. This color in no way interferes with the commercial uses of the oil and is not detrimental to its sale. The odor, on comparison, shows that the pressed oil is somewhat superior to the vacuum-distilled oil and also to that of the commercial sample. It possesses the characteristic odor of orange peel, and in addition has a fine, fruity, very agreeable aroma. In all the samples, the oils possessed a fine, characteristic, aromatic taste. The specific gravity of the sample bought in the open market is slightly below that stated in the Pharmacopœia as the minimum limit. The vacuum-distilled and pressed oils are safely within the limits. The angles of rotation of the commercial sample and the vacuum-distilled oils agree very closely; that of the pressed oil is somewhat lower, indicating that this sample probably contains more of the valuable optically inactive constituents and less of the optically active limonin. The residue on evaporation, which may be taken as a partial measure of the freshness of the sample and also as a partial measure of the valuable constituents, varies to a considerable extent. This is to be expected, since the oils are prepared under such widely varying conditions. In a commercial examination of sweet-orange oil, Schimmel & Co. have placed the residue on evaporation at 2 to 4 per cent.[1] Often the residue on evaporation falls below 2 per cent, as in the sample of oil purchased in the open market. Rarely does it exceed 4 per cent, and when it does the conclusion may be drawn that the oil is either quite old or it is adulterated. Both the oils extracted by the methods outlined in this bulletin fall within the limits fixed by Schimmel & Co., the oil obtained by pressure having the highest evaporation residue. This high percentage is due to the larger quantities of the waxes and nonvolatile constituents which were pressed out and probably indicates a better grade of oil.

The quantity of oil absorbed by the sodium-bisulphite solution is of special interest. Although the tabulated results do not represent the true percentage of aldehydes present in these oils, they do serve as a comparative estimate of the commercial value. Of the three samples of oil, that which was obtained by heavy pressure is by far the best. The hand-pressed oil ranks second and the vacuum-distilled oil third. The last two, however, agree closely in the percentage of oil absorbed.

The results of the comparison of the various oils indicate that the oils prepared by the methods described in this bulletin are equal, if not superior, to the hand-pressed oil obtained abroad, and of the three samples the one obtained by heavy pressure is the best.

COMMERCIAL POSSIBILITIES.

From the results of numerous experiments and from its favorable acceptance by the trade after an examination of the oil, it is recommended that only the pressed oil be produced. The necessary outlay in money for equipment is small, and the product is of an extremely high grade. In addition to the peeling machine, the apparatus and material required are as follows:

Pressing device (fig. 4).
Still (fig. 5).
Separatory funnels.
Glass or tin funnels.
Filter papers.
Tin containers.
Unslaked lime.

The pressing device as illustrated is of the simplest type. A press equally efficient and of more rapid manipulation can readily be constructed by any mechanic. The drum should not exceed 12 inches inside diameter and should be about 16 inches high. It should be built of staves 2 inches thick and 2 inches wide, forming with each other a tight joint. Each stave should have a groove one-fourth of an inch by one-fourth of an inch lengthwise on the inside face, and this groove should continue across the end of the stave at the bottom end of the drum. A lining of sheet brass perforated with holes one-sixteenth of an inch in diameter and about an inch apart should be placed inside the drum. The press bag of 10-ounce canvas should be made slightly greater in diameter than the drum and about 6 inches longer than the drum, in order to allow for the folding of the canvas over the top of the cake.

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[1] Schimmel and Co. Semi-Annual Report, Oct.-Nov., 1906, p. 35.

It was found expedient to release the pressure several times in the treatment of a cake, since this apparently facilitates the extraction of the oil. In commercial operations where several presses would be employed this could be done readily by passing the drum from one screw to the next, inasmuch as these screws would probably all be mounted in one frame having a common base.

The still can be purchased from dealers in pharmaceutical and chemical supplies. Heat can be supplied by gas, gasoline, kerosene, or wood stoves. Separatory funnels, glass or tin funnels, filter paper, and any other minor apparatus can be obtained from the dealers mentioned. Burnt lime can also be readily obtained from local dealers. The entire outfit occupies but little floor space and is comparatively inexpensive.

COST OF PRODUCTION.

After the plant is equipped, the cost of producing the oil will depend entirely upon the price paid for the waste fruit and the cost of labor. In the experimental work here recorded the cost was about 15 cents for extracting the oil from a standard field box of oranges of approximately 100 pounds, and it is believed that on a commercial scale the cost will be no greater for fruit delivered at the factory door. By using several presses, as previously mentioned, it is believed that even this cost can be reduced materially.

YIELD OF OIL.

In some preliminary experiments the yield of oil was found to vary greatly according to the variety, stage of growth, climatic conditions, and quality of the fruit. From data secured by laboratory tests on several varieties from a great number of localities the yield was found to range from 2.5 to 9 ounces of oil per 100 pounds of fruit. Satisfactory yields of oil have also been obtained by this process from frosted fruit and from fruit in the earlier stages of stem-end rot or showing only a small decayed spot. The peeling machine, however, will not handle frosted fruits which have become soft or fruits which show large areas of decay.

In commercial experiments with cull fruit obtained at the packing houses at Orlando, Fla., the average yield of oil per 100 pounds of fruit was about 5 ounces. It may safely be assumed that from 4 to 5 ounces of oil can be extracted from every standard field box containing approximately 100 pounds of ordinary cull oranges. At the average price paid for orange oil for the past 10 years the gross returns would be from 47 to 59 cents per field box. The gross return, as determined from actual sales in the markets of New York City, of the oil produced in the experimental work was 54 cents per field box.

SUMMARY.

The extraction of sweet-orange oil is a commercial possibility in the United States. As a source of raw material for extraction the culls, drops, and inferior grades of fruit may be used. A good marketable quality of oil may be produced by the process of vacuum distillation herein described.

Pressed oil extracted by the method described is of excellent quality and a larger yield of oil is secured than by the vacuum process. The process is very simple and the cost of equipment extremely small.

The utilization of inferior or low-grade fruit for the extraction of oil will give a wider market for the better grades of fruit and also tend to greater care in the selection of these grades.

The yield of pressed oil from 100 pounds of ordinary cull fruit is estimated to be from 4 to 5 ounces, and the gross returns from this quantity of oil, based on the average price for the past 10 years, would be from 47 to 59 cents per standard field box.

The cost of extracting the oil from 100 pounds of cull fruit is estimated to be about 15 cents, and the net returns would be from 32 to 44 cents per standard field box, assuming that the fruit is delivered at the factory door.

A DETAILED DESCRIPTION OF A NEW MACHINE FOR PEELING CITRUS FRUITS.

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Scientific Assistant, Office of Drug-Plant and Poisonous-Plant Investigations.

CONTENTS.

	Page.		Page.
Introduction	13	Operating the machine	18
Description of the machine	14	Changes required for the various citrus fruits.	19

INTRODUCTION.

In the United States the production of citrus fruits, especially oranges, grapefruit, and lemons, has reached a stage where there is a demand for more careful grading of the fruit, and consequently the lower grades are gradually being diverted from the fruit trade into the manufacture of various by-products. The first step in the manufacture of these products, whether oils or other materials from the outer peel or food products from the pulp or juice, consists in removing the peel from the fruit. Owing to the tender nature of the fruit and the great variations in its shape and size, it has not been easy to accomplish this with any of the machines now on the market. It was necessary therefore to devise special machinery and apparatus which would work up the fruit at low cost and with a minimum demand on the labor supply of the citrus districts during the busy harvest season. The machine which has thus been devised not only peels the fruit with great rapidity, but also makes it unnecessary to sort the fruit prior to putting it through the machine.

The machine has been thoroughly tested at Orlando, Fla., and it has been found that by its use one man can in one hour remove the peel from 2 tons of oranges or from 3½ tons of grapefruit. The peel comes from the machine in a finely divided condition suitable for the extraction of the oil, and the peeled fruit is delivered in a condition suitable for use in the manufacture of various food products.

This peeling machine has been constructed by the United States Department of Agriculture, has been patented under United States Letters Patent No. 1186317 and is dedicated to the public.

DESCRIPTION OF THE MACHINE.

The machine consists of four essential parts, as follows:

(1) A rapidly revolving drum which removes the peel by a grating action on the fruit.

(2) A spiral feed screw which carries the fruit along the drum, at the same time rotating it in a forward direction so that the peel is removed in the form of spirals.

(3) A feed table of special construction which serves as a support for the fruit while passing through the machine.

(4) An adjustment mechanism to vary the relation of the drum, feed screw, and table in accordance with the character of the fruit to be handled and the degree of its ripeness.

The details of the machine as they appear in both perspective and cross section are shown in figures 6 to 10. Figure 6 is a perspective view of the machine; figure 7, a side view of the machine with the cover removed; figure 8, a top view of the feed table; figure 9, a cross section through the machine; and figure 10, a cross section of the conveyer. The lettering of the various parts of the machine is the same in all of the figures.

The drum (figs. 6, 7, and 9, *A*).—The drum is 11 feet in length and is made in two parts, each 5 feet 6 inches long, since it is found that if it is built in one piece there is a tendency to sag in the middle, thus causing great vibration when run at the necessary speed. Each part is built of narrow staves 2 inches wide and 1½ inches thick, bolted to cast-iron pulleys 10 inches in diameter and 3 inches face. It was found advisable to cast the pulleys with the spokes set at one side of the rim and with the hub projecting about 2 inches beyond the rim on that side, since this permits easy access to the stave bolts. Each part of the drum requires three pulleys. The end pulleys are set on the shaft, with the hubs inside, and the middle pulley is equidistant from the ends. The shaft is about $1\frac{3}{16}$ inches in diameter, and each pulley is fastened to it with a half-inch set screw.

The staves are secured to the pulleys by a quarter-inch bolt through the middle of the stave at each pulley, and the bolt heads are countersunk in the staves to at least a quarter of an inch below the surface. All the staves except three are secured by bolts through holes drilled in the rim of the pulleys, the nuts being secured on the under side of the rim. In the last three staves placed in position, the holes in the middle pulley are threaded the proper size and the cap screws turned in from the outside. The two parts of the drum are set on the shaft 6 inches apart, to permit a middle bearing to be placed in position on the frame. After the staves have been secured in place the drum is turned true, either by placing it on a lathe or by setting it in its frame and turning it by power.

The grating surface of the drum is made of No. 24 galvanized iron, cut into strips 4 inches wide and punched to form the special teeth required. These teeth are formed by a triangular punch with two sides straight and the third beveled to form the point. The punch should be adjusted so that when used on a lead block a triangular tooth will be cut, having one point exposed. The teeth are from three-sixteenths to one-fourth of an inch long, with the point raised from three thirty-seconds to one-eighth of an inch. They are about three-fourths of an inch apart each way and so placed that when the strips are in position on the drum the teeth will project in the direction in which the drum rotates. It is essential that the point and edges of the punch be kept sharp, in order to make a clean-cut tooth having a sharp point. It is desirable to mark off the strips on the sheet of galvanized iron and punch the teeth before cutting the strip, leaving a margin of at least one-half an inch on each edge. This prevents the strips from being warped out of shape in the punching process.

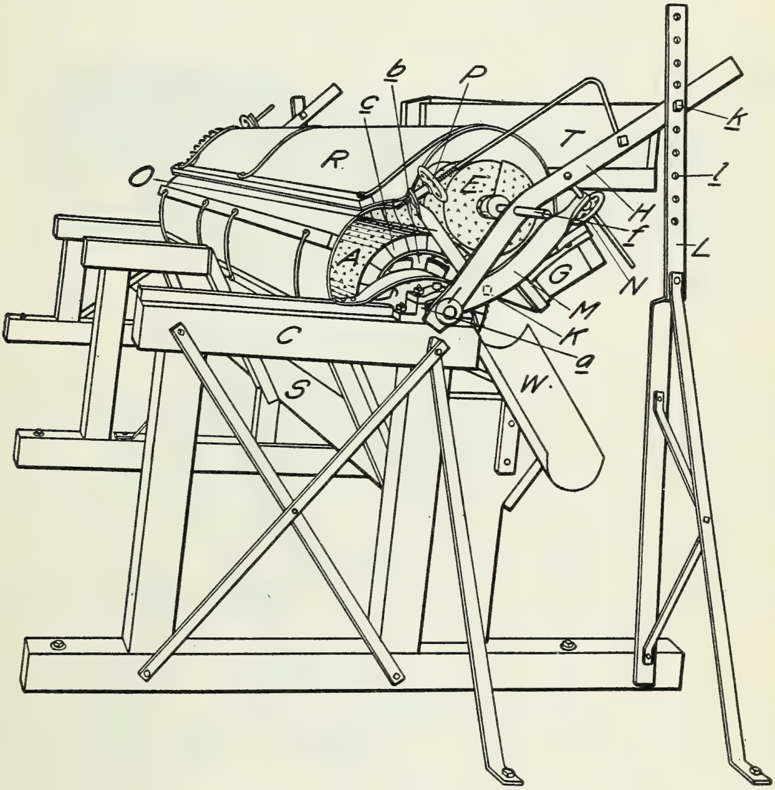

FIG. 6.—Perspective view of the peeling machine.

The strips are wound spirally on the drum until it is entirely covered and are then nailed down smooth with No. 3 nails placed about an inch apart. It is essential that no sharp corners or edges of the metal be left projecting, since these will cut the fruit and cause trouble.

The details of the frame construction are shown in figures 6 and 7. The frame is made of pieces 4 by 4 inches mortised together and properly braced with iron. At the lower end of the machine the frame is 20 inches high and at the upper end 32 inches high, so that one end of the drum is 12 inches higher than the other. The frame is fastened to the floor by lag screws, the ends being further secured by iron braces in order to receive the end thrust which is caused by the drum being higher at one end.

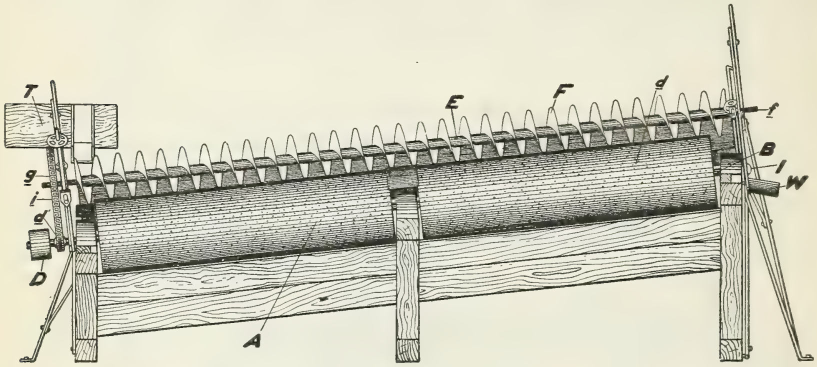

FIG. 7.—Side view of the peeling machine, with the cover removed.

The feed screw (figs. 6, 7, and 9, *E*).—The feed screw is the same length as the drum. It is built with 2-inch galvanized-iron pipe as a shaft, on which is soldered a spiral made of 22-gauge galvanized sheet iron. The flights of the spiral are $3\frac{1}{2}$ inches high and 4 inches apart, each flight being made separately. These are then united and soldered to form a continuous spiral and are set on the shaft so that they project forward about 15°. The faces of the flights are punched thickly with the 3-cornered punch, forming points about one-eighth of an inch high on the forward face. This screw is supported by pieces of a $\frac{3}{4}$-inch shaft set in sleeve collars held inside the pipe by screws. The shaft need not extend more than 2 feet into the pipe at each end.

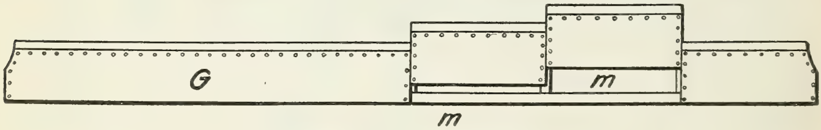

FIG. 8.—Top view of the feed table.

The feed table (figs. 6, 8, and 9, *G*).—The feed table consists of a wood or iron frame 9½ inches wide, running the entire length of the machine under the feed screw. It should be the length of the machine from outside to outside of the end frames. The top of the frame is covered with a 10-inch board, which is cut into sections as shown in figure 8. These sections are held in place by some sort of fastening on the outside edge, so that they can be drawn out at will. The upper surfaces of these slides are covered with galvanized iron, toothed on the inside half in the same manner as the flights of the feed screw but with the teeth a little smaller.

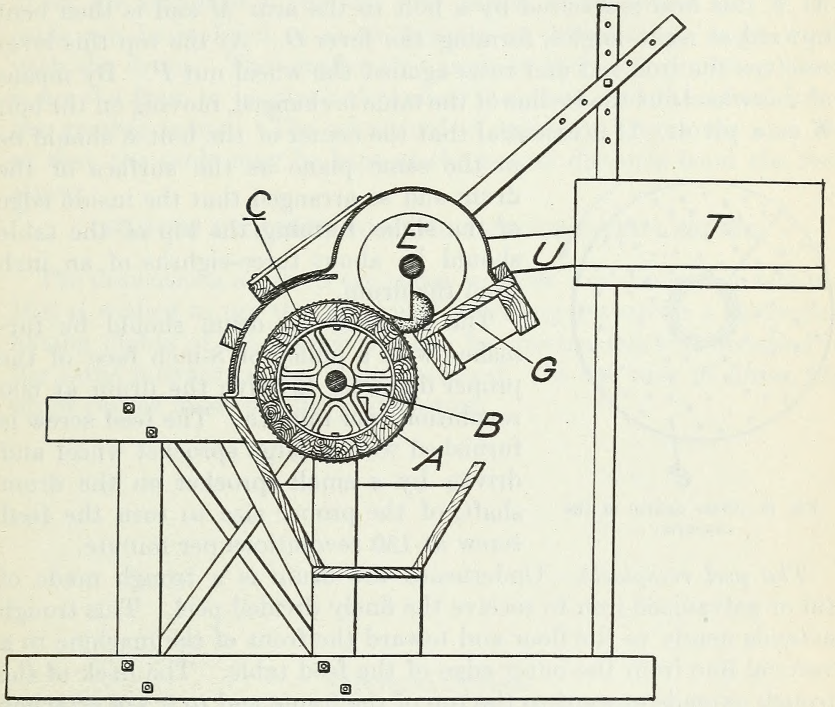

FIG. 9.—Cross section through the machine.

The adjustment mechanism (fig. 6).—The feed screw *E* is supported at each end by an iron bar *H*, attached at the lower end to a babbitted collar *a* on the drum shaft and held at the other end by a vertical standard *L*, in which are several holes *l* for receiving the bolt *k*. The hole in the iron bar *H*, through which the feed-screw shaft *f* extends, should be at such a distance that when the feed screw is in place there will be about one-half inch clearance between the edge of the screw flights and the drum. In case the machine is to be used a great deal, the bearing for the shaft of the feed screw at *f* in the arm *H* should be reinforced by a babbitted bushing to prevent wear. The short arm *M* is attached at the lower end to the same collar as *H*, and the other end rests on the wheel nut *N*, running on the rod which is secured at the upper end of the arm *H*. By means of this wheel nut the outer end of the arm *M* can be raised and lowered.

The feed table is supported by an iron arm attached underneath and forming a brace to hold the parts of the frame in position. This arm is carried up to the level of the top of the table and bent at right angles to extend in the same plane as the top of the table. At *K* this arm is secured by a bolt to the arm *M* and is then bent upward at right angles, forming the lever *O*. At the top this lever receives the iron rod and rests against the wheel nut *P*. By means of this wheel nut the incline of the table is changed, moving on the bolt *K* as a pivot. It is essential that the center of the bolt *K* should be in the same plane as the surface of the drum and so arranged that the inside edge of the slides forming the top of the table should be about three-eighths of an inch from the drum.

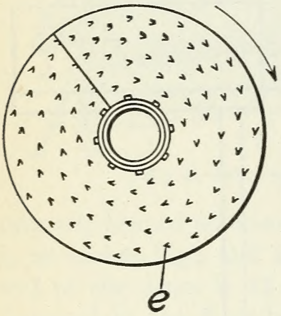

FIG. 10.—Cross section of the conveyer.

The shaft of the drum should be furnished with a pulley of 8-inch face, of the proper diameter to drive the drum at 600 revolutions per minute. The feed screw is furnished with a large sprocket wheel and driven by a small sprocket on the drum shaft, of the proper size to turn the feed screw at 150 revolutions per minute.

The peel receptacle.—Underneath the drum is a trough made of tin or galvanized iron to receive the finely divided peel. This trough extends nearly to the floor and toward the front of the machine to a vertical line from the outer edge of the feed table. The back of the trough extends upward to the top of the frame and to it are attached removable covers which entirely inclose the drum and feed screw. These can easily be removed for cleaning and for removing the peel which adheres to them.

OPERATING THE MACHINE.

The fruit to be peeled is placed in a large box (figs. 6, 7, and 9, *T*), the bottom of which is a few inches higher than the top of the drum at the lower end. From this box a narrow spout (fig. 9, *U*) extends to the edge of the feed table. The fruit rolls into this spout and is fed by hand, one at a time, between the two lower flights of the feed screw (see fig. 9), one being delivered at each revolution of the feed screw. The fruit is carried along by this screw in contact with the drum, which removes the peel by grating. As soon as the fruit comes in contact with the rapidly revolving drum it tends to spin rapidly in the opposite direction, but this is sufficiently retarded by the toothed surface of the table, which supports it, so that it is acted upon by the teeth of the drum. The toothed flights of the feed screw tend to roll the fruit forward on the table, so that the peel is removed in a series of spirals. The peeled fruit is delivered from the spout *W* (figs. 6 and 7).

In adjusting the machine for work the weight which the fruit presents to the drum can be changed by raising or lowering the arm *H* on the standard *L* (fig. 6). By means of the wheel nut *P*, the table can be inclined so as to increase or decrease the angle made with the drum. The smaller this angle is the more tendency there is for the fruit to be pinched against the drum and the more severe the grating action. The wheel nut *N* raises or lowers the arm *M*, so that the table may be kept at the proper distance from the feed screw.

CHANGES REQUIRED FOR THE VARIOUS CITRUS FRUITS.

The dimensions as given are those suitable for oranges or lemons. If it is wished to use this machine for peeling grapefruit a feed screw having flights of the proper size can be constructed and installed in the same manner as has been described. In the case of limes, the screw can be made smaller and shorter.

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